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NOTES ON THE HABITS OF CERTAIN COPROPHAGOUS BEETLES AND METHODS OF REARING THEM

By ARTHUR W. LINDQUIST, *junior entomologist, Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine*

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INTRODUCTION

Coprophagous beetles are of economic importance as well as of general interest, for severel reasons: (1) By disturbing cattle dung, the breeding medium of the horn fly (*Haematobia irritans* L.), they probably reduce the abundance of this widespread pest of cattle; (2) many species are intermediate hosts of parasites of poultry and other animals; (3) they play an important role in the interchange of soils and the incorporation of organic matter; and (4) they exhibit the instincts of maternity and progeny protection. As there appeared to be a dearth of information on the habits of these dung beetles in this country and on methods by which these insects can be reared, the following notes and observations were made at Uvalde, Tex., from time to time from 1931 to 1934.

REARING METHODS

For rearing *Copris*, *Phanaeus*, and *Pinotus* in the laboratory, boxes containing sandy loam soil to a depth of 8 to 10 inches are used. The bottoms of the boxes are removed and the walls placed on floor boards 1 inch thick and held in place with cleats. By this arrangement the walls can be lifted from the cake of soil so that an examination can be made for the immature forms. A screen-wire top is necessary to keep the beetles from escaping. Heavy clay soils which will gum together when wet should be avoided. The soil should be kept moist and fresh dung supplied every few days. Apple boxes 18 by 12 by 12 inches are suitable for rearing *Copris* and *Phanaeus*, but longer boxes should be used for rearing *Pinotus*. *Canthon laevis* Drury can also be reared in these boxes, but since this

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species needs considerable room for dung rolling an outside cage is more desirable.

Onthophagus can be reared in pint mason jars containing 2 inches of sand on which is placed a small quantity of dung. By emptying the jar every few days the parent beetles and the pellets of manure containing the eggs can be recovered.

The immature stages of *Aphodius* and *Ataenius* have not been studied in the laboratory, but they can probably be reared in fresh, uninfested cow dung on sand or soil in a small cage. They do not roll or bury dung, but pass their immature existence within the dropping.

HABITS OF VARIOUS COPROPHAGOUS BEETLES

COPRIS REMOTUS Lec.

This coprophagan makes its burrow at the margin of dung. Cattle droppings are usually utilized, but on one occasion a burrow was found at the edge of carnivore dung, and at another time several burrows were examined near the contents of the paunch of a sheep carcass. After a burrow has been excavated, the beetle grasps a small portion of dung with its fore legs and backs down into the tunnel, returning in a few minutes to repeat the procedure and continuing for one-half to 2 days. The beetles are very cautious, and movements of the observer cause a quick retreat into the tunnel.

The female makes 2 types of burrows, 1 for feeding and 1 for rearing progeny. If the dung is to be used for adult food, it is shaped into a ball an inch or less in diameter and placed in a circular cavity at the lower end of a 4- to 8-inch burrow, similar to that made by *Copris tullius* Oliv.[1] The cavity for the rearing of progeny is much the same except that it is larger, deeper in the ground, and a larger portion of dung is shaped or kneaded into a flat mass about 1 inch thick and 2 to 3 inches in diameter. From this mass are constructed the ovoid to spherical egg balls, the diameters of which average 1 inch and three-fourths inch. The balls are formed one at a time and the entire procedure requires 2 to 3 days. From 1 to 8 egg balls have been found in a nest, but the usual number is 4 to 6 (fig. 1). Whenever the nests of this species were examined, the female beetle was invariably in the cavity with her progeny. Further study revealed that after oviposition is completed she plugs the opening to the tunnel and remains with her progeny, hovering about and over the balls until the larvae complete development and emerge as adults.[2] After about 2 weeks the balls were very smooth and had no ragged surfaces such as are characteristic soon after construction. Apparently the beetle occupies her time in polishing and caring for the balls and probably guards against possible enemies. Fresh dung was frequently put in the box, but the beetle

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[1] LINDQUIST, A. W. AMOUNT OF DUNG BURIED AND SOIL EXCAVATED BY CERTAIN COPRINI (SCARABAEIDAE) (I). Jour. Kans. Ent. Soc. 6: 109–125, illus. 1933.

[2] Similar observations on *Copris hispanus* L. were made in Europe by Fabre as reported in the following publication: FABRE, J. H. SOUVENIRS ENTOMOLOGIQUES . . . ÉTUDES SUR L'INSTINCT ET LES MOEURS DES INSECTES. v. 8, pp. 128–150. 1897. Fabre's account was included in a translation of some of his works, by Teixeira de Mattos: TEIXEIRA DE MATTOS, A. [L.] THE SACRED BEETLE AND OTHERS, BY J. HENRI FABRE. 425 pp. New York. 1924. This apparent parental care was observed in the case of *Scarabeus sacer* L. in Corsica. GOODMAN, A. DE B. OBSERVATIONS ON THE LIFE-HISTORY OF SCARABEUS SACER. So. London Ent. and Nat. Hist. Soc. Proc. 1927–28: 42–47. [1928.]

could not be induced to leave her brood. If the balls are taken away and the nest is destroyed, the beetle usually begins another home immediately, but she may construct feeding burrows for a few weeks first. One female was taken from her brood and placed on top of the soil in the box, but she seemed to make no effort to find her progeny, and several days later was found in a feeding burrow. When the egg balls were removed from a nest and put on sand in salve boxes, they matured normally.

In a test in which the egg balls were taken from a female shortly after their construction, 6 nests, containing a total of 24 eggs, were constructed successively from May 10 to July 26. In another test, 12 nests, containing a total of 41 eggs, were obtained from a reared female over a 14-month period. As a check in this test a female in another box was allowed to stay with her progeny for long periods, but this female constructed only 5 nests, containing a total of 15 eggs. It appears that in the field only 3 or 4 broods normally are produced by one female in a year, but in the laboratory from 6 to 10 broods can be obtained by removing the progeny.

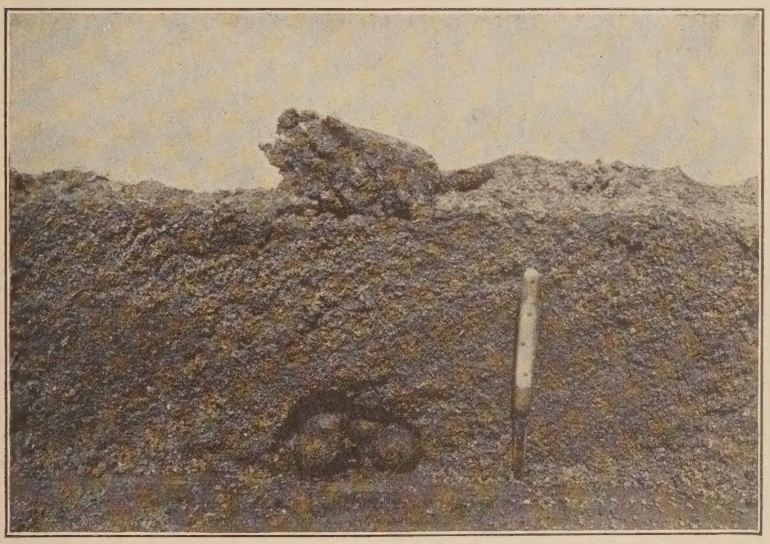

FIGURE 1.—Brood chamber of *Copris remotus*. Usually from 4 to 6 egg balls are made in one chamber.

The egg is usually, but not always, located at one of the longitudinal poles of the ball. A slight elevation indicates the point at which an egg will be found in a small, smooth depression just under the surface. The egg is elongate, slightly curved, rounded at both ends, smooth, and glistening white with a very faint green tint. The average diameters are 4.33 by 2.90 mm.

It is somewhat difficult to determine exactly the length of the incubation period, but it appears to be from 5 to 10 days under laboratory conditions. The period of development from egg hatching to adult emergence in the spring and summer averaged 49 days,

with a range of 38 to 69 days. The pupal period ranged from 12 to 37 days. Of 48 reared beetles 32 were females and 16 males.

To determine the number of larval instars and the time in each instar it is necessary to open the ball, remove the larva for measurement of the head capsule, replace the larva, and repair the ball, which after a number of examinations may become ragged and weak. It was nearly impossible to find the cast skins except immediately after molting. Three larval instars were found, and the data concerning them are shown in table 1.

TABLE 1.—*Data on instars of three dung beetles*

Species	Instar	Time in instar			Measurement of head capsule		
		Maximum	Minimum	Average	Maximum	Minimum	Average
		Days	*Days*	*Days*	*Mm*	*Mm*	*Mm*
Copris remotus	First	4	2	2.9	2.1	1.8	1.97
	Second	5	2	3.7	2.5	2.2	2.35
	Third	(1)	(1)	(1)	3.0	2.8	2.94
Phanaeus triangularis	First	6	3	4.1	2.8	2.5	2.66
	Second	4	4	4.0	3.2	3.0	3.10
	Third	(1)	(1)	(1)	4.2	4.0	4.12
Canthon laevis	First	3	1	1.8	2.2	2.0	2.10
	Second	3	2	2.5	2.8	2.4	2.65
	Third	(1)	(1)	(1)	3.2	2.9	3.13

[1] Not determined.

Eggs have been obtained as early as March 20, and as late as October 10.

The longevity of the adult is interesting. One reared female lived 644 days, and several beetles have laid eggs over two seasons. Under normal conditions females probably live 4 years and possibly longer. Since the parent stays with her progeny until they emerge as adults, only 3, or sometimes possibly 4, batches of eggs are laid in a year. Twelve batches have been obtained from a single female during a 14-month period without a decrease in number of eggs per batch, when the progeny were taken away from the nest from 5 to 14 days after deposition, and it seems reasonable to suppose that 4 years would normally be required to lay 12 batches of eggs.

PHANAEUS TRIANGULARIS (Say)

The burrows of this beetle have never been found on the plains around Uvalde, but after rains they have been observed about 30 miles north of Uvalde on the escarpment of the Edwards Plateau, but only in the river valleys. Although the river bottoms close to Uvalde have been searched, only one burrow has been discovered. Apparently the species seeks localities close to streams and does not thrive in hot, dry plains.

This species also burrows at the edge of cattle droppings. In the field these burrows have been found to be branched, the main tunnel being from 6 to 12 inches long and about three-fourths inch in diameter, and the branch, which is used for dung storage, from

3 to 8 inches in length and 1 inch in diameter. Eggs have not been found in the field.

In the breeding boxes the egg chamber is always deeper in the soil than the feeding tunnels. Dung is taken down into a cavity about 1½ to 2 inches in diameter and formed into a single, nearly perfect sphere. The surface of the dung ball is then plastered with soil to a thickness of nearly one-fourth inch except at one point, where it is applied more thickly, giving the ball a pyriform appearance (fig. 2). This coating of soil probably prevents excessive desicca-

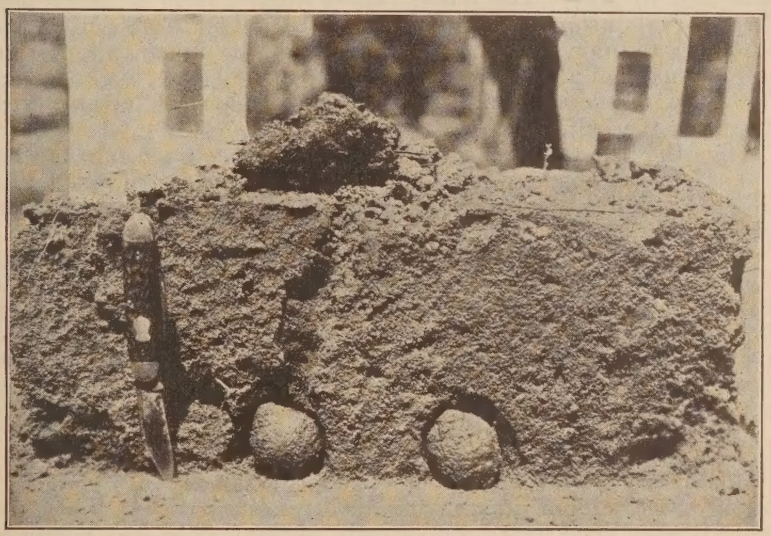

FIGURE 2.—Completed egg balls of *Phanaeus triangularis* in their individual chambers.

tion of the larval food. The egg is laid in the smaller end of the ball, just under the surface, in a small earthen cell or cavity. The earthen cap is somewhat rounded and often contains a tiny hole. The egg is not in contact with the manure, as in the *Copris* ball, and when the egg hatches the larva digs its way into the interior and feeds on the food provided by the parent. That this stocky, clumsy beetle is able to build such a beautiful ball, construct the smooth egg cavity, and cap it without crushing the fragile egg is indeed marvelous. The egg balls are more nearly uniform in shape and more symmetrical than are those of *Copris*. When the egg ball is completed, the beetle leaves to construct another, and apparently the progeny is forgotten. Several days are required to dig a burrow and construct the egg housing.

The egg is similar to that of *Copris*, but larger, the diameters being approximately 6 by 4.3 mm. It is elongate, subcylindrical, and glistening white. The incubation period is from 6 to 9 days.

Two females taken in the field and kept together in a box laid 34 eggs from May 20 to October 2, 1932. Unfortunately, the beetles died during the extremely cold weather in February 1933. Egg deposition would probably have continued into the following summer.

A group of reared specimens which emerged in May and June 1933 did not commence oviposition until September.

For a study of the immature stages the egg balls were placed singly on slightly moistened sand in pint mason jars capped with solid tops. Of 24 specimens that were reared, 18 were females. There seems to be not more than one generation a year. The average period from egg hatching to adult emergence was 344 days, with a minimum of 269 and a maximum of 391 days. The eggs deposited in September produced adults only a few days later than those laid in May. The pupal period ranged from 37 to 50 days. Three larval instars were found, and the data are shown in table 1. When the larva was a few weeks old, the inner ball of dung had shrunk and the surrounding husk of soil was easily broken. The fully developed larva constructed a spherical, creamy-white cell inside the ball.

When the ball was opened slightly, the larva ejected into the hole an anal paste which, when dry, formed a hard, cementlike plug. This process of repair has been observed with other species of dung beetles.

An interesting observation pertaining to feeding habits was made of a male of *Phanaeus triangularis* in a breeding box January 29, 1933. The insect was feeding at the margin of a patch of dung, and several observations daily showed a continuous consumption of food and a constant ejection of feces until a string several feet long had accumulated. Approximately 2 cubic inches of dung was consumed in 7 days.

CANTHON LAEVIS (Drury)

This species is widely distributed, and its actions in carving out and rolling away balls of dung are frequently observed. At times, particularly after rains, two dozen or more beetles may be seen cutting up a dropping, and sometimes the entire dung patch is destroyed. In hot, dry weather 50 to 100 beetles may be found milling around inside a dropping. One unusually large dropping was estimated to contain 600 beetles. The insects probably congregate in this manner for feeding and protection until they are ready to prepare for their progeny.

Canthon laevis females roll away and bury balls of dung for food and for egg deposition. The greatest activity is in the spring, and very little rolling has been observed in the fall. When it has rolled a ball about for an hour or more and found a place for burial, the beetle begins to dig under and around the sphere until it gradually disappears into the hole. Upon excavation a few days later the beetle's exit tunnel is found extending down to a depth of 2 to 5 inches, where the ball is lying in a neat spherical cavity; or, if the dung ball is used for adult food, the beetle may be found feeding on the manure and the material reduced to shreds. In either case the ball is from five-eighths to nearly 1 inch in diameter, including the coating of soil which has been accumulated in the rolling process. In her underground chamber the female apparently finishes the ball by applying an additional coating of soil at some point for the egg cavity or cell, making it pyriform in shape.

When conditions are optimum, hundreds of earthen mounds covering the burrows of these beetles can be seen within a few hundred yards. In one pasture 50 mounds were found on a $\frac{1}{20}$-acre plot and at another place a count on a $\frac{1}{12}$-acre area showed 168 mounds.

The egg is creamy white and similar to other dung-beetle eggs; the average diameters are 5.45 and 3.60 mm. The incubation period is 4 to 8 days and the pupal period 10 to 14 days. The egg balls used for study of immature stages were obtained by digging up nests in the field immediately after rains.

The average developmental period from egg hatching to adult emergence at the laboratory in the spring and summer was 35.4 days, with a minimum of 29 and a maximum of 44 days. There are indications that in the field the developmental period is shorter. Three larval instars were found, and the data are shown in table 1.

The larvae of this species, as well as of *C. lecontei* and probably other species of *Canthon*, at intervals make holes in the smaller end of the ball and excrete a black, moist, pasty mass, which soon hardens and forms a collar of protruding nodules around the small end of the ball. The excreta may occasionally be found on other parts of the ball.

CANTHON LECONTEI Har.

This species, although much smaller than *C. laevis*, has similar habits. The beetles are abundant in the spring and occasionally are very active in October. The ball they construct and roll is from one-fourth to three-eighths inch in diameter and is buried from 1 to 3 inches in the ground. The incubation period is 4 to 6 days. In June the period from egg hatching to adult emergence averages 24.3 days.

CANTHON CYANELLUS Lec.

Although this species is fairly abundant at Uvalde, the eggs or immature stages have never been seen. The beetles are found in cow droppings but most abundantly at meat baits. They are attracted to the meat baits in blowfly traps, and often 25 or more are drowned in the bait pans. They have been observed at small carcasses and human excrement. A beetle was once seen rolling a ball that had been carved from a piece of decaying liver.

ONTHOPHAGUS ANTHRACINUS Har.

Specimens of *Onthophagus anthracinus* Har. are found in dung from March to December, and a hundred or more have been counted in a single dropping. Species of *Onthophagus* perform their dung burial under a dropping. A burrow is dug vertically into the ground to a depth of 1 to 4 inches, and dung is transported into the lower extremity, where it is fashioned into a crude ball in which an egg is laid.

Reared females have deposited from 43 to 67 eggs over periods of 22 to 42 days. Only 1 or 2 eggs are laid daily, and they average 1.56 by 0.74 mm in diameter. The average developmental period from egg to adult in summer was 38.4 days, with a range of 36 to 52 days. Notes on the number of instars are not complete, but indications are that there are three.

ONTHOPHAGUS PENNSYLVANICUS Har.

This species is common at Uvalde and has a wide distribution over the United States. Its habits appear to be similar to those of *O. anthracinus*, but the egg and ball are smaller. A few specimens have been reared, and the developmental period is about the same as that of *O. anthracinus*.

PINOTUS COLONICUS (Say)

This species, the largest of the dung beetles studied, has been found only north of Uvalde. The burrowing habits in the field are similar to those of *P. carolinus* (L.) previously described by the writer.[3] Three beetles from the field were obtained in the summer of 1932, and two of these died the following spring. The remaining beetle laid five eggs before an accident caused her death. The egg is deposited in a mass of manure, which has the appearance of being pushed into a shapeless cavity branching away from the tunnel. The egg is enormous, about one-half by one-fourth inch in diameter. There is apparently only one generation a year.

APHODIUS spp. and ATAENIUS spp.

These species deposit their eggs in dung, and the larvae develop within the droppings. *Aphodius lividus* (Oliv.) is abundant at Uvalde, on one occasion 1,113 specimens being counted in a cow dropping. Adults have been observed during the winter in the field. The developmental period has not been determined, but it is indicated from collections in caged cow droppings that 25 to 45 days is required.

THE ATTRACTION OF COPROPHAGOUS BEETLES TO CARCASSES AND MEAT

In southwestern Texas dung beetles, particularly *Canthon laevis*, are commonly seen in bait pans of blowfly traps. From a few to several hundred dead beetles are often found in the water in bait pans. The following species have been found in bait pans:

Canthon laevis	Very abundant.
Canthon lecontei	Do.
Canthon cyanellus	Abundant.
Phanaeus triangularis	Occasional.
Copris remotus	Do.
Onthophagus spp	Do.

Many species of dung beetles have been taken at meat baits over the southern part of the United States, and they are occasionally observed at small carcasses. The beetles are probably attracted to the meat by the odor. Meat may serve as food for the beetles, but it is not necessary in breeding them at the laboratory.

COPROPHAGOUS BEETLES AS A NATURAL CONTROL OF THE HORN FLY

The species principally responsible for dung dispersal in southwestern Texas are *Canthon laevis*, *Phanaeus triangularis*, and *Pinotus colonicus*. At times, particularly in springs when the rainfall

[3] LINDQUIST, A. W. See footnote 1.

is plentiful, large quantities of cattle droppings are disturbed by these beetles. No comparative data are at hand on the effect of these insects on horn-fly breeding, but probably fewer horn flies would mature in a dropping that is nearly destroyed. The following observations indicate what sometimes occurs: On April 30, 1932, 12 fresh droppings were examined west of Uvalde, and they were all from one-half to almost totally disintegrated by *C. laevis*. On May 1, 1932, 100 fresh droppings were examined north of Uvalde, and three-fourths were from one-half to almost totally destroyed, in some cases only a cubic inch of dung remaining. In the second instance *C. laevis*, *P. triangularis*, and *P. colonicus* were responsible for the dispersal of dung. The disturbing of droppings by the smaller species of dung beetles in order to hasten desiccation probably causes an unfavorable condition for the horn-fly larvae. There are, however, long periods when the larger species are not active in the field, although activity is fairly constant in the breeding boxes.

Frequent rains and high humidity increase the activity of these insects, particularly in the spring and summer. It is suspected that in long dry periods large numbers of the beetles are killed as they are ready to emerge from their cells, the balls becoming hard and imprisoning these insects.

Consideration has been given to the possibilities of artificial encouragement of certain of these insects with an objective of horn-fly control, but it is believed at present that efforts along other lines, especially with reference to the parasites of horn flies, would be more productive.

SUMMARY

In order to study the habits of coprophagous beetles more closely than was possible in the field, several species were reared in the laboratory by placing females in boxes or jars containing sandy soil supplied with fresh dung every few days.

These beetles, which are called "dung beetles" because they construct balls of dung in which to deposit their eggs, show many interesting variations in the manner of constructing and placing the balls and in caring for their developing brood. Some species dig a burrow, usually at the edge of cattle droppings, and carry the dung into it for the construction of the ball; others roll the ball first and then bury it. Most species form balls for adult food as well as egg balls. In some cases several balls are found in one burrow, while in others the egg balls are placed singly. Some species remain in the nest until the developing brood emerge as adults, while others desert their progeny after completing the egg ball. Females that remain in their nests will construct new nests if their progeny are removed.

Notes on the life histories of four of the most common coprophagous beetles—*Copris remotus*, *Phanaeus triangularis*, *Canthon laevis*, and *Onthophagus anthracinus*—are given.

Dung beetles are also attracted to carcasses and decayed meat. They are frequently found in bait pans of blowfly traps in southwestern Texas.

Because of their disturbance of cattle dung, the breeding medium of the horn fly (*Haematobia irritans*), dung beetles are believed to act as a natural control of this pest.

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THE DUTCH ELM DISEASE ERADICATION PROJECT: FEDERAL, STATE, AND LOCAL COOPERATION

By L. H. Worthley, *in charge, Dutch Elm Disease Eradication, Bureau of Entomology and Plant Quarantine*

INTRODUCTION

This circular is prepared expressly for the property owner who is interested in elms because of their real as well as aesthetic value and for the municipal and county shade-tree officials who are charged with the care of park and street elms. It contains a summary of the present situation, a brief statement of the objective and methods of governmental agencies, and suggestions for the active participation of the public in the Dutch elm disease eradication program.

THE DUTCH ELM DISEASE

DISTRIBUTION

The original home of the Dutch elm disease has not been determined. It was probably present in Belgium, France, Germany, and the Netherlands by 1920. At present practically the entire area in Europe south of Scotland, Denmark, and Prussia is included in the disease area. There is no report of a concerted effort to control the disease on the Continent.

The disease entered this country probably in elm burl logs imported from Europe. Diseased logs have entered at New York City, Baltimore, Norfolk, and New Orleans and have been shipped to or through Cleveland, Cincinnati, Dayton, Indianapolis, Chicago, Kansas City, Louisville, Knoxville, and other cities. Many of the logs that were intercepted were invaded by bark beetles as well as the fungus which causes the disease.

The disease has gained a strong foothold around the port of New York City, where over 7,600 infected trees have been found within 50 miles of this port. Infected trees have been found in six other areas, and in the numbers given, as follows: Cleveland, Ohio, 10; Cincinnati, Ohio, 1; Baltimore, Md., 1; Indianapolis, Ind., 4; Old Lyme, Conn., 1; and Norfolk, Va., 1. In the major disease area and in outlying areas there probably are infected trees that have not been located.

CAUSE AND SYMPTOMS

Graphium ulmi (*Ceratostomella ulmi* (Schwarz) Buisman), the fungus that causes the Dutch elm disease, is known to be parasitic only on elm and the closely related Japanese zelkova. When introduced into the sapwood it causes the formation of gums and resins in the water-conducting vessels, and when the water flow is critically reduced or stopped the tree may die. After the death of a diseased

tree or the transfer of the fungus to dead and dying material. *Graphium ulmi* may grow in insect tunnels and in cracks developed in the wood and bark.

The most conspicuous external symptom of the Dutch elm disease is the wilting, and sometimes yellowing and dropping, of the leaves of the infected branch or entire tree. The gums and resins appear as a brown discoloration in the form of dots or a ring in one or more recent annual rings. Usually short brown streaks in the cambial region can be seen when the bark is peeled.

Other elm wilt diseases, such as Verticillium wilt and Cephalosporium die-back, may produce somewhat similar symptoms. The only known method of distinguishing between the Dutch elm disease and these diseases is by laboratory tests. When small chips from specimens of diseased trees are placed in a culture plate, the fungus grows readily and within about 4 days can be identified. Several specimens cut from recently dead or dying parts of the tree are required for these tests.

INSECT CARRIERS

The economic importance of many elm insects has only recently been accentuated because of the possibility that they are carriers of the Dutch elm disease. Many of these insects, therefore, have not been carefully studied to determine their range, prevalence, and habits. Some of the engraver bark beetles that feed on healthy elms have been found to be disease carriers. If the adults emerge from a diseased tree, they may carry the Dutch elm disease fungus and introduce it into a healthy tree as they feed in the twig crotches. However, since the carrier-fungus relationship is apparently physical and not biological, all insects and other agencies associated with elms may be important factors in the spread of the disease.

The larger European elm bark beetle, *Scolytus scolytus* (Fab.), the most important carrier in Europe, is not known to be established in the United States, although it has been intercepted in European elm burl logs. The smaller elm bark beetle, *S. multistriatus* Marsh., considered a carrier in this country, is established in New England, southeastern New York, New Jersey, and eastern Pennsylvania. There is evidence to indicate that this area includes at least two infestations of this beetle, one reported near Boston in 1909 and another perhaps older one at New York City. Preliminary scouting indicates that there may be a scolytus-free area between these two infestations. *Hylurgopinus rufipes* (Eichh.), the American bark beetle with habits similar to those of *Scolytus*, has been collected throughout most of the northern range of the American elm.

ERADICATION PROGRAM

OBJECTIVE

The immediate control and ultimate eradication of the Dutch elm disease in the United States is the primary objective of the governmental agencies engaged in the work. To accomplish this objective, the early location and prompt destruction of all material infected with *Graphium ulmi* is deemed essential. The final cost of the project and the number of elms that are killed before the disease is eradicated will depend largely on the timeliness and the degree of thoroughness of the work each year.

SCOUTING

Systematic scouting of an area several times each summer over a period of years appears to be the most practical way of locating all the diseased elms in that area. The period from May 15 to August 15 is the most satisfactory time for scouting, June and the early part of July being the most desirable part of this period. Scouts assigned to a definite area are required to examine each elm systematically for symptoms of the Dutch elm disease. Small branches are cut from all elms that show wilting, yellowing, or dropping of the leaves. If the typical sapwood discoloration is present, the scouts collect suitable specimens for the laboratory diagnosis. A "Graphium suspect card", giving the location and general condition of the tree, is made out for each set of specimens.

ERADICATION

A list of all trees that are found by the laboratory to have the Dutch elm disease is submitted to the proper State official. He then makes arrangements with the owner for the removal of each tree. In many instances, local governments or property owners have removed the diseased trees on their property. Otherwise, the diseased trees are removed by the State and Federal organizations. Because the wood from these trees is infected with the fungus that causes the disease, all wood must be burned immediately to destroy the fungus and insects which may be present.

SANITATION WORK

It is recognized that cut and fallen elm wood as well as elms that have died from other causes may support *Graphium ulmi* and many possible insect carriers. Moreover, the fungus may be present in sickly elms and produce a chronic form of the disease. In such cases the Dutch elm disease symptoms may be masked by the general sickly condition of the trees. In order to reduce this source of the fungus, a concerted effort is being made to destroy all such elm wood and trees in the major disease area and in a small zone around it. The removal of dying elms, in this phase of the program, is limited to those that have declined to a point when they are no longer of real value.

COOPERATION OF THE PUBLIC

There are at least four important phases of the Dutch elm disease eradication program in which the general public may materially assist the governmental agencies.

LOCATION OF DISEASED ELMS

Plans are being made for systematic scouting of the area within 50 to 60 miles of New York City, the outlying areas where diseased trees have been found, and other areas exposed to imported diseased material. The total size of these areas is strikingly small when compared to the whole area in which the Dutch elm disease may possibly exist. Individuals in all parts of the area can assist by reporting or collecting suitable specimens from trees that show the symptoms of the disease. Within the work areas a requested inspection will be made by the scouts as they periodically scout the area in which the tree is located. For the sake of economy, it is suggested that six specimens about three-fourths inch thick and 6 inches long from trees outside the work areas be submitted directly to the main office

of the Dutch elm disease eradication project.[1] Upon request, a supply of Graphium suspect cards to send in with each set of specimens will be forwarded to interested persons. The timely location and proper diagnosis of all diseased elms in the United States is an important step in the eradication.

COLLECTION OF ELM INSECTS

The collection and correct identification of all insects commonly associated with elms will aid in planning the field work. Careful examination of dead and dying elms may reveal the presence of the large *Scolytus* bark beetle in this country. In the same manner the range of both the American and the small European bark beetles may be more definitely defined. Furthermore, the general observation of all elm insects and their habits may lead to the discovery of other insect carriers. The value of such a survey depends not only on the thoroughness and carefulness with which it is done in an area but also upon the number of areas that are surveyed.

SANITATION WORK

The sanitation work of the governmental agencies is confined largely to the removal of dead and dying elms. Local governments and property owners can cooperate by doing this work on their own properties, thus permitting more extensive Federal work. Acceptance by each individual of the responsibility for cleaning up and burning each year all cut and fallen elm wood and brush on his place before May 1 will likewise be a definite contribution. Furthermore, property owners may supplement this program by pruning dead and dying wood from elms that are yet of some value and should be retained. This type of clean-up work, carried out uniformly in the disease area, would materially reduce the amount of Dutch elm disease fungus and number of insect carriers in the area. Such sanitation work, if sponsored by civic organizations and garden clubs, could be profitably applied to an entire community.

CARE OF ELMS

In order to keep the amount of dead and dying elm wood at a minimum and to avoid the cost of annual sanitation work, elms should be kept in good condition. There are no data available to indicate definitely what effect the vitality of an elm has on the chances of its becoming infected or killed by the Dutch elm disease. There is, however, a direct relationship between the low vitality of elms and their infestation by the bark beetles which are known carriers of the disease. Careful spraying of elms to prevent damage by leaf-eating insects will make it possible to do more rapid and thorough scouting in the elm leaf beetle and cankerworm areas. It appears, therefore, that feeding, spraying, and other operations that tend to increase the vitality of elms may at least indirectly contribute to the Dutch elm disease eradication program.

[1] At the present time (March 1935) the address is: Field Headquarters, Dutch Elm Disease Eradication, Room 916, County Office Building, White Plains, N. Y.

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